Mars Hill Windfarm Post-Development Sound Level Study Peer Review

MARS HILL, MAINE

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A number of Mars Hill residents granting impromptu interviews to discuss their personal experiences with the UPC wind farm noise,

The Mountain Landowners Association and their independent reviewer Mr. Richard Bolton for his findings and literature review[1],

The Second International Meeting on Wind Turbine Noise, Lyon, France, September 2007 speakers for their willingness to share research and papers presented at the meeting,

The Plant Manager for the Klondike Oregon wind farm facility who granted a site tour and contact information for local residents, and

Unnamed Wasco, Oregon residents willing to discuss their personal experiences with noise impact from a large windfarm facility.

Review Basis

UPC Wind Management LLC/Evergreen Wind Power LLC (UPC) operates a 28 unit wind facility along the ridge line of Mars Hill in Mars Hill, Maine. At the request of the Maine Department of Environmental Protection (MDEP) this peer review is undertaken to provide expert opinion as to:

> "Whether the post-development report is reasonable and technically correct according to standard engineering practices and the Department Regulations on Control of Noise(06-096 CMR 375.10) and
>
> Whether the reports provide a reasonable basis upon which to determine compliance or non-compliance with the operational noise limits set forth in the Control of Noise rules and the variance given in Department Order L-21635-26-A-N/L-21365-TG-B-N, dated June 1, 2004."

The post-development ambient and operational noise studies were completed by Resource Systems Engineering (RSE)[2] in December 2006 (ambient) and May 2007 (ambient and operation). Each section of the June 21, 2007 report will be generally critiqued unless detailed criticism is given.

1.0 Introduction

The stated objective of this sound level study is to compare wind farm operation sound levels with predicted estimates and evaluation of the ambient sound levels in the vicinity of the wind farm.

¶ 5, pg. 1 mentions that MDEP order number L-21635-26-A-N grants variance from MDEP noise standards based on the wind farm having no predicted unreasonable adverse impact on protected locations and measurement issues related to wind speeds.

UPC initiated an ambient and operations sound level study late in 2006 after receiving concerns from persons residing in nearby protected locations.

2.0 Sound and Decibels

Informational

3.0 Site Description

A thorough site description is given detailing both the development and surrounding area. Wind turbine specifications and locations by profile view are thoroughly detailed.

4.0 MDEP Standards

Applicable sound regulations are identified and detailed with application of MDEP order number L-21635-26-A-N variance.

5.0 Sound Level Model Estimates for Wind Farm Operation

The sound level prediction model using CADNA/A software program bases predicted levels on 3 mph downwind conditions, which are moderately conservative for general developments. Since optimal wind farm operating conditions require much higher wind speeds, greater variations from predicted levels may occur during upwind/downwind conditions as a result of the refractory qualities of the atmosphere with respect to sound propagation.

Calm surface conditions do not necessarily correlate with hub level wind speed. This is often seen in a neutral atmosphere in the evening and nighttime hours or downwind conditions on the leeward side of the ridge, when hub level wind speeds maybe considerable, but contrasting surface conditions are calm or light and variable.

High surface wind levels will be most commonly seen in monitoring locations where wind flow is unobstructed by the ridge and nearby tall trees. These conditions will generally correspond to up wind or crosswind patterns when source noise levels would be expected to be less (acoustic shadow conditions).

Annual wind rose data is presented showing a predominant wind direction and speed from the northwest through west (~35% at wind speeds above 12 mph) and a significant portion from the southeast.

Given the factors of Mars Hill predominant wind directions, hub level/surface wind potential disparities and potentially increased atmospheric refraction above predictive model, increased operations sound pressure levels above the predictive model may occur along the eastern side of the ridge.

6.0 Ambient Sound Levels

Ambient sound levels were measured during December 20-22, 2006 prior to wind farm operation. It appears that sites were selected somewhat symmetrically around the facility and proximal to protected locations as a basis for comparison with operational levels and identification of possible quiet areas. Additional sites were added later during compliance measurements (May 2007).

The RSE Report indicates that sound measurement instruments utilized were of the type Larson-Davis model 812, 824 and appropriate acoustic calibrators. Microphones were fitted with standard Larson-Davis wind screens and devices were mounted on tripods.

The Larson-Davis reference manual for the Model 812[3] (page C-10) states the following,

> **"What a microphone measures**: *A microphone detects more than just sound*. The motion of a microphone diaphragm is in response to a force acting on it. The force can be caused by a number of sources only one of which are we interested: sound. Non-sound forces are: (1) direct physical contact such as that with a finger or a raindrop; (2) those caused by the movement of air over the diaphragm such as environmental wind or blowing;…"

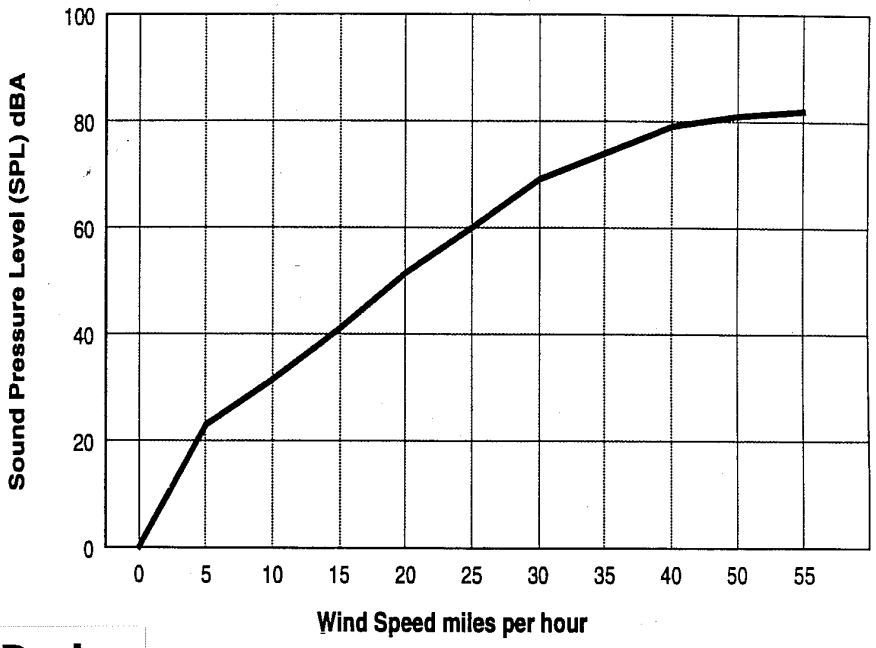
In order to correctly appreciate the adverse effects of wind forces on sound measurements Larson-Davis' David Ahlstrom, Repair & Calibration Manager has provided the following technical information documented by Larson-Davis for their standard windscreen systems included with the models 812 and 824, the (WS001):

8.7 Wind Noise

The microphone is mounted such that winds up to 20 m.p.h. do not cause vibration levels at the microphone resulting in microphone outputs above 60 dBA.

Using the capability of the Larson•Davis RMS to interface directly to windspeed sensors, a complete Model 2100K microphone system with rainhat, windscreen, and bird spikes was tested in actual variable wind conditions out-of-doors. Data were logged simultaneously for windspeed and A-weighted sound pressure level; resulting data are plotted in Figure 16.

FIGURE 16. Wind Screen Noise for the Model 2100K Outdoor Microphone Syste



Larson Davis
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In the above figure, A-weighed sound pressure levels are correlated over a 0-55 mile per hour (0-88 km/hr) range. The 50 dBA limit is reached at 20 miles per hour or 8.9 m/s.

It is clear from Larson-Davis literature and testing of their microphone windscreen system that wind speeds above 12 mph produce microphone forces registered as sound levels that may adversely effect low level sound level measurements. The Larson-Davis findings are consistent with other studies that have been the basis for wind threshold specification for acceptable outdoor noise measurement conditions found in many standards and regulations.

Secondary windscreen designs and products are available when outdoor measurements are required during excessive wind speeds. In addition, the Larson-Davis model 824 optionally is equipped with a wind tachometer providing a wide array of wind data for correlation with sound measurements including wind threshold exceedance level to minimize degradation of sound level measurement integrity by excessive wind forces (non-sound).

Surface wind speed and direction were not measured at each ambient location, but rather several miles away at the Presque Isle Airport. There may have been some correlation between the airport readings and the unobstructed monitoring locations, but otherwise as report observations note several locations did not seem to correlate with reported conditions.

As noted in ¶ 8, pg. 16, when wind speeds dropped to less than 10 mph hourly average sound levels at monitoring locations were less than 40 dBA and during calm or light winds overnight readings were below 35 dBA. In contrast to ambient measurements possibly made under high wind conditions, these decreased levels were possible because they remain significantly greater than microphone wind interference thresholds.

7.0 Operating Sound Levels

The 96-hour sound measurement period in May of 2007 included standard windscreen protection for instrument microphones (see ambient sound level windscreen discussion) and off-site surface wind speed measurements (Presque Isle Airport) resulting in indeterminable, site-specific wind speed and direction conditions which ultimately impacted operating sound level, tonality and short duration repetitive sound measurement accuracy.

Review of the data provided reveals that in general, the greatest one hour average sound levels at most measurement locations were at or slightly above 50 dBA, but average levels at these same respective sites were below 50 dBA. Although General Electric specified windmill tonal and short duration repetitive sound levels are inconsequential with respect to MDEP chapter 375.10, actual operating condition tonality and a short duration repetitive sound has not been ruled out by measurement given potential wind interference uncertainty.

8.0 Findings and Recommendations

The May 2007 operation sound measurements were in fact recorded "during wind conditions at or exceeding the predicted mean wind speeds with wind from predicted predominant directions".

RSE recommends to the UPC Wind additional sound level measurements of wind farm operations during fall and winter periods using ground level anemometers at measurement positions.

Conclusion - (Peer Review)

This ambient and operating level sound study was to an extent compromised by the use of inadequate microphone wind protection and/or site-specific wind condition information.

Springtime operation noise level measurements alone do not represent climate factors, such as, snow-cover and blade icing which have been documented as acoustic factors enhancing windmill sound propagation and production which may contribute to significant seasonal operation sound level variations.

It is the opinion of the reviewer that this initial assessment of the project indicates substantial compliance, but requires further measurement technique refinement with additional measurements to fully demonstrate results that are reasonable and technically correct according to standard engineering practices and the Department Regulations on Control of Noise(06-096 CMR 375.10) with operational noise limits set forth in the Control of Noise rules and the variance given in Department Order L-21635-26-A-N/L-21365-TG-B-N, dated June 1, 2004.

Recommendations

This reviewer concurs with RSE recommendations to:

- use ground level anemometers at monitoring locations, and
- complete future sound level measurements representing other seasons of the year (specifically, representative winter measurements).

A sound measurement assessment should occur when monitoring locations have snow-cover and preferably during potential conditions for wind turbine blade icing.

In addition to site-specific wind condition monitoring, should be the addition of secondary windscreens for recording ambient and operational sound levels when microphone wind interference exceeds levels less than 6 dBA below sound levels to be measured, utilizing recommendations prescribed by the equipment manufacturer.

Post Review Discussion & Recommendations

The following discussion and recommendations are directed toward the Maine Department of Environmental Protection Site Location of Development noise standards as specified in Chapter 375.10. and their application by the department.

Sounds emitted from an outdoor source are diminished by several factors including divergence, atmospheric absorption, ground surface factors, foliage, building construction (indoor noise concerns) and miscellaneous other factors. Although the usual greatest

diminishing factor, divergence, is unaffected by sound frequency the remaining factors are frequency dependent. Increased low-frequency-content, sounds associated with windmill operation tend to propagate better and penetrate light weight building structures with much greater effectiveness than broadband sounds.

In addition to wind mill low frequency sound emission, is the periodic "swooshing" or amplitude modulation produced as blades pass the support tower. These low-frequency modulations have been reported as penetrating and annoying.

> Recommendation #1: Operation sound measurements should be required during periods or seasons consistent with predominant operating conditions and factors enhancing sound propagation toward nearby sensitive receptors. Measurement periods should include measurement site snow-cover conditions.
>
> Recommendation #2: Sound level limits should be conservatively applied by the department given their periodic, low frequency modulating annoyance factor.

Mountainous typography especially arising from plains or rolling hills, such as Mars Hill Ridge and its immediate surroundings, give rise to broadly varying atmospheric conditions over relatively short distances. For example, vigorous ridgeline winds may be consistent with up-wind low elevation surface conditions, but be contrasted downwind at surface levels by light or even calm conditions. Given these potential variations, upwind receptors would experience high level masking and "shadow" atmospheric refraction conditions minimizing ridgeline source sounds, whereas downwind receptors would experience minimal masking and atmospheric refraction lapse conditions that would enhance ridgeline source sounds.

Ambient and operation sounds measured at high wind speeds (>12 mph) may produce non-noise artifact lessening the integrity of measured data. This confounding element can lead to false conclusions regarding ambient and operation sound levels. Manufacturer microphone and windscreen specifications must be appropriately applied.

> Recommendation #3: Mountainous wind farm operation and ambient sound measurements at protected locations should be required with site-specific wind speed conditions.
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> Recommendation #4: Sound measurements required at wind speeds > 12 mph should be done in a manner consistent with manufacturer microphone/windscreen recommendations and/or appropriately specified secondary windscreens.

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[1] *Assessment of the Sound Level Study for the Mars Hill Wind Farm ,* Mr. Richard Bolton, August 13, 2007 Rev 2a

[2] *Sound Level Study & Operational Sound Level Monitoring Maine Department Of Environmental Protection Order No.L-21635-26-AN*, Resource Systems Engineering, June 21, 2007, File 030625

[3] *Model 812 Reference Manual*, I812.01 Rev. C, Larson Davis Inc., 2003